Heteroepitaxy of gallium-selenide on Si(100) and (111): New silicon-compatible semiconductor thin films for nano structure formation

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Silicon has been the backbone of modern electronics for decades; however, it is not readily compatible with some new types of electronics, such as optoelectronics or spintronics. We aim at overcoming this limitation by combining gallium-selenide (GaxSey) materials with silicon (Si) through heteroepitaxial growth. GaxSey materials are lattice matched with Si, and are optically and potentially magnetically active semiconductors. Their unusual crystal structures, layered GaSe and defected zinc-blende Ga2Se3, may be exploited for unprecedented low dimensional structure formations.

In the presentation, we demonstrate that GaxSey thin films can be grown epitaxially on Si(100) and (111) substrates into various nanostructure forms, namely 0-dimensional (0-D) "dots", 1-D "wires", 2-D "layers", and 3-D "bulk". We have found that hexagonal layered GaSe is formed on Si(111) with or without arsenic termination (Si(111):As), and defected zinc-blende Ga2Se3 is formed on arsenic terminated Si(100) (Si(100):As). The surfaces of GaSe/Si(111) and Ga2Se3/Si(100):As are covered by triangle nanodots and oriented nanowire structures, respectively. We propose that different symmetry and bonding of the substrate surfaces induces different configurations of vacancies, resulting in the distinct surface nanostructures. Through this study, we propose a generalized concept describing the stable structures of the selenide materials, applicable in both nano- and macro-scopic scales.